Specification and Composition of Network Services in Future Internet Architectures

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ABSTRACT

The inadequacies of the current Internet data and control planes to adapt to changes have given rise to several new proposed Internet architectures. In many cases, these new architectures enable a variety of "services" in the network that can be used to customize network functionality and to add new features after deployment. One key challenge to such network services is that they need to be composed from various networking resources at runtime. Therefore, it is critical to develop methods for accurately specifying the semantics of network services and composing them dynamically. In this article, we propose a service description semantic, discuss how to formalize the service composition problem and use the formalization in conjunction with a logic planner to provide an efficient solution .

Categories and Subject Descriptors

C.2.6 [**Computer-Communication Networks**]: Internetworking

Keywords

future Internet architecture, network service, data-path policy, automated planning

1. INTRODUCTION

A major constraint impeding further growth of the Internet is its inability to adapt to new services, frameworks, protocols and such in the core of the network. This is restricting deployment of entities principal to next generation Internet architectures. ChoiceNet aims to address this by building a networking architecture that is designed with choice as a core principle [4]. The design is based on the interactions of technological choices with economic incentives to create a sustainable, innovative core for existing and future networks. Such interactions are illustrated in Figure 1.

In ChoiceNet's architecture, every usable entity on the network is formally represented as a *service* in a *marketplace* where they are advertised. ChoiceNet suggests exposing this choice of services to customers. The providers can architect their solutions by dynamically composing a set of services to respond to customers' requests. This runtime formulation, like SILO's methods [1], allows service-centric networks to establish connections that are customized to meet customer requirements. To build and support this architecture, it is imperative to have an accurate, standardized definition for every network service and to develop computational methods for optimal service composition.

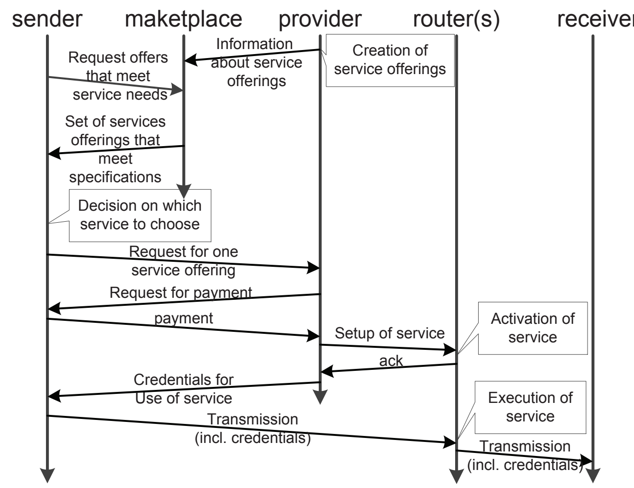

Figure 1: Interaction Timeline.

In this poster, we propose a novel approach that aims at addressing the problem of service description and composition for service-centric network architectures.

2. SERVICE DESCRIPTION

The ChoiceNet architecture is based on the idea that everything in the network, like link bandwidth, storage or software services offered on nodes, is a service. Before considering service composition, we need a formal definition of a service, such that providers can submit a service to the marketplace in a standardized manner. Based on the work in [3], we describe a service as:

$$S =< spec, \Delta_{pre}, \Delta_{post} > \quad (1)$$

where *spec* is the service's specification set that may include any necessary parameters; Δ_{pre} are *preconditions* that need

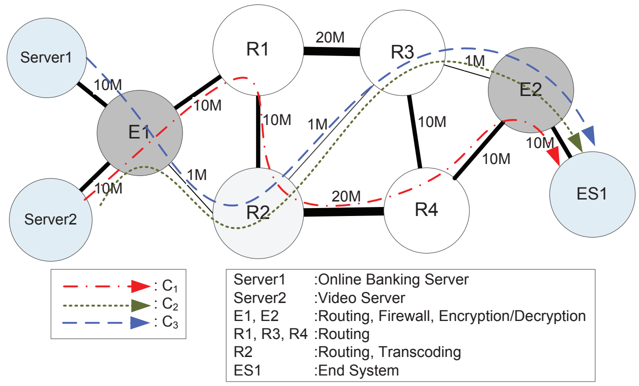

Figure 2: Service composition framework in ChoiceNet.

to be satisfied for the service to be executed; and Δ_{post} are *postconditions* of the output produced by the service. Both these sets of characteristics include protocol and data semantics. To describe these characteristics exhaustively, we use the description semantics that are proposed in [3].

The composed service may be offered as a multi-service set by a single service provider or as a aggregated service offered by a third party provider comprising of multi-authored services. This means that customers requesting for a service could be third party providers architecting their service sets from service authors.

3. AUTOMATED SERVICE COMPOSITION IN CHOICENET

Network topology information can be gathered through data path discovery. The various services are registered by the providers on the marketplace. This means that the marketplace in ChoiceNet has global view of services and the network topology. To respond to a customer request, the marketplace has to compose a set of services that inherently dictates the path to be taken and the order in which services are executed along the path. The path should be optimal or near optimal in cost, latency or bandwidth, according to the customer's choice.

In Figure 2, C_1 is a request for a video stream over a high bandwidth link. The server streams video in 1080p Quicktime format and the end system can receive only a H.264 format which form the pre and post conditions. This means a transcoding service needs to be applied on the stream somewhere along the service path. The service composition for C_1 is:

$$C_1 =< Server2, E1, R1, R2, R4, E2, ES1 > \quad (2)$$

C_2 is a request for a video stream over a low bandwidth link. The preconditions and postconditions remain the same. This results in a service composition of:

$$C_2 =< Server2, E1, R2, R3, E2, ES1 > \quad (3)$$

C_3 is a request for an encrypted data stream for an online banking session over a low bandwidth link. The service composition for C_3 is:

$$C_3 =< Server1, E1, R2, R3, E2, ES1 > \quad (4)$$

This example shows how the choice of service paths can be requirement based, like a customer's choice and also service dependent, like high bandwidth for video and low bandwidth for data.

If we represent every communication request as $< I, G >$, where I is the precondition of the source service, and G is the postcondition of the destination service, this problem can be reduced to an AI planning problem. The topology information can be used as one of the probable inputs to a logic planner such as LPG [2] that can be used to solve the planning problem. The planner can then provide a list of alternatives $(\pi_1, p_1), (\pi_2, p_2)...(\pi_n, p_n)$ with their associated costs. Here each π_i is a sequence of services $(S_{i1}, S_{i2}...S_{in})$.

The steps of service composition can be described as follows:

1. The customer submits a service request $< I, G >$ to the marketplace.
2. The marketplace consults the service registry and the topology database and with this information, uses a logic planner/reasoner to obtain several optimal paths of service.
3. The customer selects a service path from the list of alternatives $(\pi_1, p_1), (\pi_2, p_2)...(\pi_n, p_n)$.
4. The marketplace hands over the service composition to the control plane to push policies onto the data plane for service provision along the chosen path.

The service composition and routing problem is an interesting challenge for service-centric networks. We believe ChoiceNet's global topology and service information, when properly transcribed into a planning domain language and input to a planner will be able to help us obtain optimal service compositions. These compositions should assist in handling the service composition and routing issue in an efficient manner.

4. ACKNOWLEDGMENTS

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5. REFERENCES

[1] R. Dutta, G. N. Rouskas, I. Baldine, A. Bragg, and D. Stevenson. The SILO architecture for services integration, control, and optimization for the future internet. *Communications, 2007. ICC'07. IEEE International Conference on*, pages 1899–1904, 2007.

[2] A. Gerevini and I. Serina. LPG: a planner based on local search for planning graphs with action costs. *Proc. of the Sixth Int. Conf. on AI Planning and Scheduling*, pages 12–22, 2002.

[3] S. Shanbhag, X. Huang, S. Proddatoori, and T. Wolf. Automated Service Composition in Next-Generation Networks. In *Distributed Computing Systems Workshops, 2009. ICDCS Workshops '09. 29th IEEE International Conference on*, pages 245–250, 2009.

[4] T. Wolf, J. Griffioen, K. L. Calvert, R. Dutta, G. N. Rouskas, I. Baldine, and A. Nagurney. Choice as a principle in network architecture. In *SIGCOMM '12: Proceedings of the ACM SIGCOMM 2012 conference on Applications, technologies, architectures, and protocols for computer communication*. ACM, Aug. 2012.